Rock Chips

Summer 2011

Alberta Geological Survey

New Approaches to Surficial Geology Mapping in Northern Alberta

As part of a multi-year initiative, the Alberta Geological Survey (AGS) is continuing its regional surficial geology mapping program in northern Alberta. These maps accommodate the increasing need for geological information in northern Alberta to support infrastructure development, mineral exploration, forestry and land-use planning.

The ongoing status of surficial geology mapping in Alberta.

Previous Approach

Surficial geology mapping traditionally involves establishing the lithology of sediments and associated landforms through field observations, which are combined with the geomorphological interpretation of stereoscopic airphotos. These provide a geologist with a 3-D view of the landscape, allowing the sediment-landform associations to be mapped according to their origin, distribution and spatial extent.

In northern Alberta, this approach works well in agricultural areas where the limited vegetation cover allows an unimpeded view of the landscape and where accessibility permits examining and ground-truthing sediments. However, as the mapping program has progressed into more remote regions of the boreal forest, these methods have proven ineffective, particularly in areas where field access is limited and the dense vegetation cover obscures underlying landforms. Geological interpretation using airphotos is further hampered by vegetation patterns caused by non-geological factors, such as tree health, forest fire, tree regrowth and anthropogenic ground disturbance.

Recent AGS surficial geology maps (Maps 553, 554 and 555) are based on a new mapping approach developed at the AGS, which incorporates airborne LiDAR (Light Detection and Ranging) imagery. This new approach overcomes the 'vegetation problem' and allows a geologist to accurately interpret the landscape based on the sedimentology and geomorphology, while still using the vegetation patterns and the clues that they provide about the nature of the underlying sediments.

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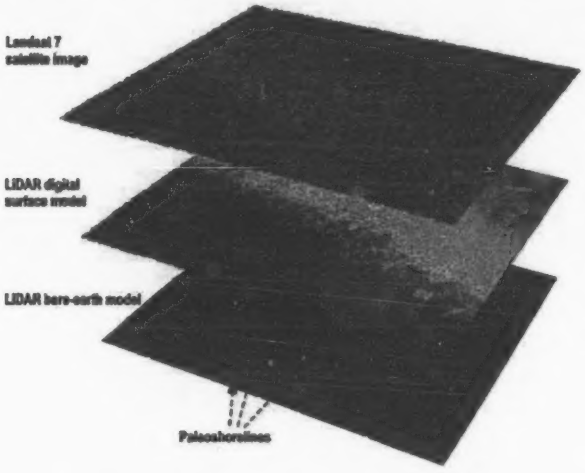
LiDAR-Based Methodology

Digital elevation models (DEMs) derived from high-resolution, airborne LiDAR are becoming increasingly available for northern Alberta. This method uses rapid, infrared laser pulses that measure the distance to the ground, creating a 'point cloud' of millions of elevation measurements. In areas where the ground surface is covered by vegetation, a single laser pass can generate multiple returns from both the vegetation and the underlying ground surface, with the last pulse (final return) generating the ground topography beneath the vegetation. Although fewer pulses reach the ground in densely vegetated areas, the high density of pulses means that LiDAR can still measure the ground topography with a high degree of precision. This technology offers many advantages over airphoto analysis or other remote-sensing methods (e.g., satellite imagery) for geomorphological investigations.



Example of Landsat 7 satellite imagery (top), LiDAR first return digital surface model (middle) and shaded-relief, bare-earth model (bottom) of NTS 84A/SW. Glacial lake paleoshorelines are clearly visible in the bare-earth model but are completely masked by the vegetation in the other imagery.

The LiDAR 'bare-earth' model, created from the final returns of the pulse data, is used for surficial geology mapping and has a 1 m horizontal grid spacing and about a 30 cm vertical accuracy. This is used to generate shaded-relief images that simulate the effects of shadows cast by sunlight across the landscape, highlighting subtle geomorphological features. Relief-shading, however, is subject to strong directional bias, with linear landforms only being highlighted when oriented perpendicular to the chosen sunlight direction. To overcome this, shaded-relief images are generated from eight illumination

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Past and present issues of *Rock Chips* may be viewed on the AGS website at www.ags.gov.ab.ca.

AGS reports are available for download for free from our website at www.ags.gov.ab.ca.

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directions and then reduced into a single image using principal component analysis (PCA), which statistically removes redundancy in the data with minimal loss of information.

Shaded-relief, principal component analysis image showing tracts of parallel, low-amplitude, ice-moulded bedforms (fluting) across a till plain, close to North Wabasca Lake (NTS 84A/SW).

LiDAR shaded-relief images have proven highly effective in landform mapping. However, geomorphology alone is not enough to delineate the boundaries of all sediment-landform associations, particularly in areas of low relief. Spatial variations in the lithology of surficial sediments are also documented by differences in the overlying vegetation cover. In the absence of distinctive geomorphological changes, such differences are more accurately detected using optical remote-sensing methods. We integrated this information within the new mapping process by using high-resolution, SPOT-5 satellite imagery and 1:60 000 scale airphotos that are orthorectified using a LiDAR DEM to remove topographic distortions and produce a planimetrically correct image. We then viewed these photos using ERDAS' Stereo Analyst® for ESRI® ArcGIS 9.3 and 3-D glasses or a stereoscopic viewing attachment. This allows a geologist to view a full 3-D representation of the landscape and vegetation features within the ArcGIS environment. Digital stereoscopic airphotos offer several advantages over their analogue counterparts, because the scale can be varied up to the resolution of the photograph to identify small-scale features. Image-processing methods, such as contrast stretches, can further enhance landscape features.

To map areas characterized by extensive wetland cover, Landsat 7 multi-spectral images are used. Landsat 7 bands 1 to 5 and 7 are processed using PCA to reduce data redundancy between bands and highlight differences between peatland types (e.g., fen and bog). When paired with LiDAR data, all of these imagery sources can be turned into synthetic stereo pairs for 3-D stereoscopic viewing. Future maps will be based on a quantitative approach to mapping these organic deposits, using the different spectral signatures of bog, fen and different forest types within an automated classification approach. This will reduce map production time while enhancing the systematic description of these deposits.

Mobile GIS

The combination of LiDAR and satellite imagery can be used quantitatively as a predictive mapping tool that geologists can use to derive preliminary interpretations regarding the distribution of organic deposits and surficial sediments. During this summer's fieldwork, AGS geologists will test modern, ruggedized tablet PCs with integrated GPS units. These tablet PCs will enable a geologist to integrate multiple data sources in real-time to provide better evaluation of sediment-landform associations while in the field. Furthermore, the PCs will carry the full range of imagery and preliminary geological interpretations, with surficial geology features being added or modified while in the field. A significant advantage of this technology is that draft versions of field maps can be assembled and continually evaluated in a 3-D environment while mapping.

New Map Products

The integration of remote-sensing technologies has increased the effectiveness and accuracy of surficial geology mapping, resulting in new map products for northern Alberta. The Alberta Geological Survey released the first of these during 2010 to 2011 for the Lesser Slave River area (Map 553, NTS 83O/SE), the Faust area (Map 554, NTS 83O/SW) and the Thickwood Hills area (Map 555, NTS 84A/NE). These maps show a significant increase in detail when compared to adjacent map areas for which only airphotos were used in the geological interpretation. Specifically, the number of recognized sediment units and landforms, including fluting, hummocky moraine, doughnut moraine and gravel deposits, is at least two times greater. In comparison to adjacent map areas, we also found more than three times the area covered by mass-movement deposits and landslides, which are readily detected using LiDAR imagery. This information is presented on the maps as a transparency over the LiDAR relief-shaded image, which provides a visual link between the geological interpretation and the geomorphology. In turn, this further enhances the map quality and confidence in the geological interpretations. These maps and accompanying digital datasets are available from the AGS website at www.ags.gov.ab.ca/publications. ❖

Bedrock Geology Projects

Mapping exposures of geological units is one of our key activities this summer to create an updated geological map of the province. Geologists from the the Bedrock Geology section of the AGS will work in various locations for several projects:

1. ***Clastic Stratigraphy:*** In northern Alberta, geologists will measure and describe outcrop sections of the Fort St. John, Colorado and Smoky groups, as well as the Dunvegan Formation, to refine the location of geological contacts and to better understand rocks being mapped in the subsurface. Fieldwork will take place on outcrops exposed along the Peace River and Wabasca River and on the flanks of the Caribou Mountains.

2. ***Carbonate Stratigraphy:*** In northeastern Alberta, Devonian strata outcrop locally along river valleys. Fieldwork directed at measuring and examining Devonian outcrops began along the Clearwater and Athabasca rivers last summer and will be completed this summer. New work along the Slave and Peace rivers will also be conducted to further examine Devonian stratigraphy in northeastern Alberta.

3. ***Rocky Mountains and Foothills:*** The AGS continues to work on a digital geological compilation map of the mountains in Alberta, summarizing more than 100 years of previous geological mapping in the Rocky Mountains and Foothills. Fieldwork will concentrate on ground-truthing the geological units from north of Smoky River to the Alberta-British Columbia border and west of Abraham Lake, as well as sampling selected clastic units in the central and southern segment of the mountains in Alberta. Samples for paleontological and isotopic analysis will be collected to better constrain the age of selected stratigraphic units and the timing of deformation along major thrust faults.

Quaternary Geology Projects

4. Alberta Geological Survey is continuing its regional surficial geology mapping program in northern Alberta, this year focusing on the Valleyview and Fox Creek areas. These maps describe the distribution and origin of surface sediments and associated landforms and accommodate the increasing need for geological information of northern Alberta.

5. In addition to these surficial-mapping activities, AGS geologists will conduct fieldwork in the Keg River and Chinchaga River areas for the first provincial-scale surficial geology map of Alberta.

6. In southern Alberta, we will work in the Hand Hills and Cypress Hills areas, mapping the distribution and internal architecture of sands and gravels to better define the Paleogene for Alberta's table of formations, as well as construct a geological framework to complete a groundwater inventory of the region.

Applied Geoscience Projects

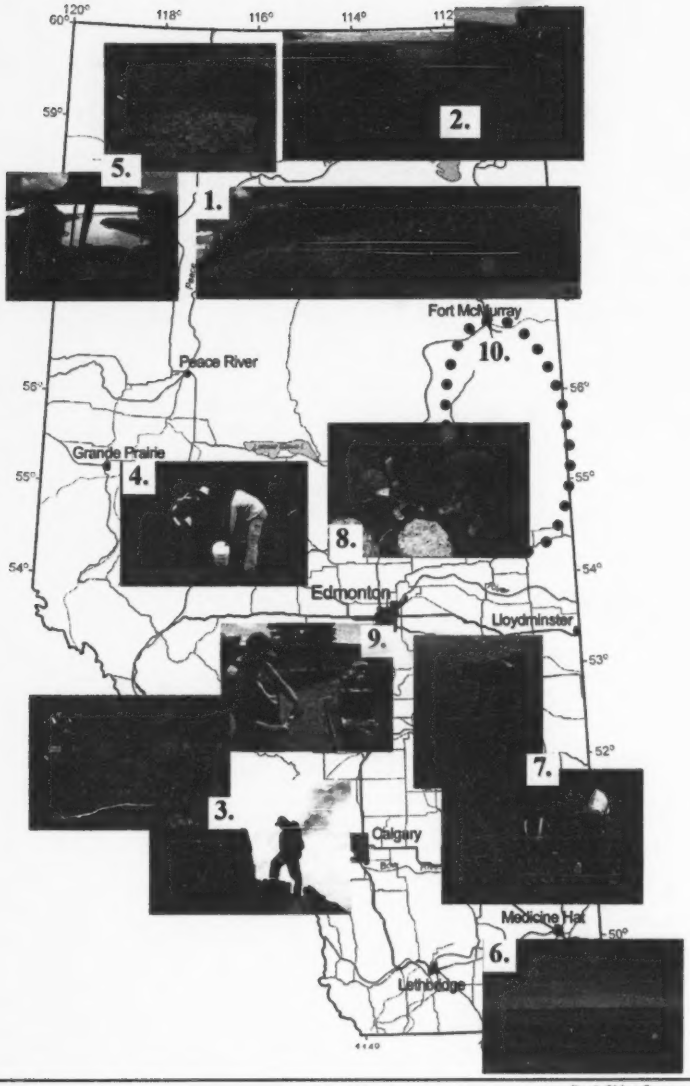
7. The Springs Compilation project consists of mapping existing springs data from internal and external sources. This year's field trip will visit many springs that are easily accessible by road. Field measurements, such as pH, temperature, electrical conductivity and flow measurements or an estimate of flow volume, may also be taken depending on the spring.

8. The Induced Seismicity project members are creating a database of Alberta earthquakes. The database will provide the background necessary to investigate natural and induced seismicity. This summer, AGS will collaborate with University of Alberta staff to increase the number of seismographs in central and eastern Alberta.

9. The goal of the Saline Aquifer Mapping project, is to provide public-domain, digital maps of the major saline aquifers from the crystalline basement to the lowermost aquifer of the Colorado Group. We will sample in the Edmonton region to understand saline aquifer water chemistry.

10. The Oil Sands Surveillance and Monitoring (OSSM) project is piloting the use of satellite-based, Earth observation (EO) technology in the oil sands areas to enhance regulatory capabilities of the Government of Alberta. The AGS is heading OSSM with partners Alberta Environment, Alberta Sustainable Resource Development, the Canadian Center for Remote Sensing and the Canadian Space Agency.

The overall aim of the OSSM is to test the application of EO technologies in the lower Athabasca and Cold Lake oil sands, evaluate their effectiveness and make recommendations using these technologies in future monitoring. Scientific advisory committees will be for each pilot project, consisting of experts from federal and provincial governments, industry and academia. ❖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Lethbridge

Meet Our Staff
Chris Schneider, Carbonate Stratigrapher

How long have you been with AGS?
2 years

What is your field of expertise?
Carbonate geology and marine paleoecology, with emphasis on the Devonian and Carboniferous Earth systems interactions

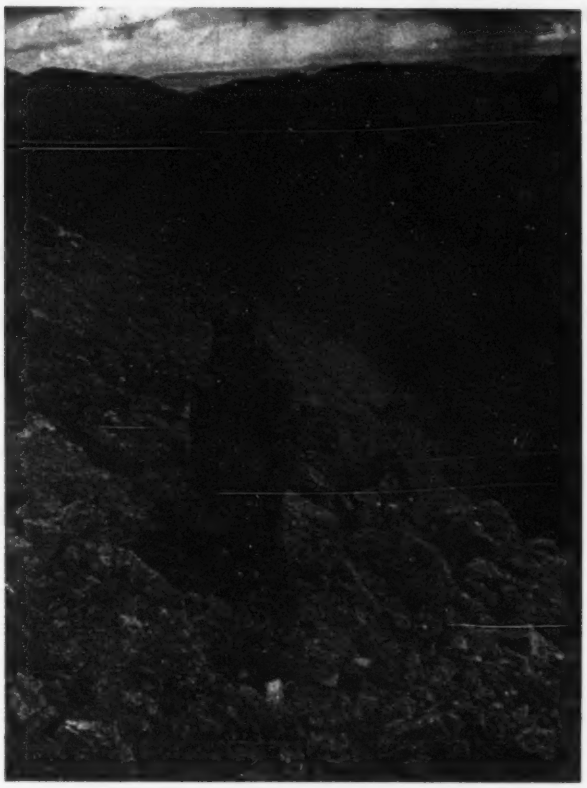
What is your professional claim to fame?
I am the world's only specialist on Paleozoic archaeocidarid sea urchins, the precursors to all modern sea urchins. I have named three new species and have several more to write up on my days off. I am also one of only three specialists worldwide working on a group of enigmatic fossils called hederellids.

Where is the most interesting place on Earth that you have worked?
At sea, on the Pacific Ocean: I pursue research outside of my AGS responsibilities, and this includes wearing my marine biology hat! I'm researching the human effects on ecosystems inhabiting the ocean floor.

What is your favourite geological place/feature in Alberta?
That's a tough one. I find every outcrop is exciting. Perhaps because I'm actively working on the area, the Waterways outcrops along the Athabasca and Clearwater rivers top the list, but the Front Range comes in a very close second!

Why did you pick your career?
I accidentally fell into geology. I spent several years working in theatre and film, but decided it wasn't for me. I returned to college, where I became interested in European Paleolithic archaeology, but I was turned off by the politics of the discipline at the time. One summer I took a just-for-fun, one-day fossil hunting class and had a blast. I took a few geology classes that fall and was thoroughly hooked. I'd always had a love of nature, and (soft rock) geology was not only the enjoyment and appreciation of nature as we see it today, but also nature throughout the entire history of the world! ❖

Meet Our Staff
Francisco Moreno, Engineer



How long have you been with AGS?
Five and a half years

What is your field of expertise?
Petroleum geomechanics

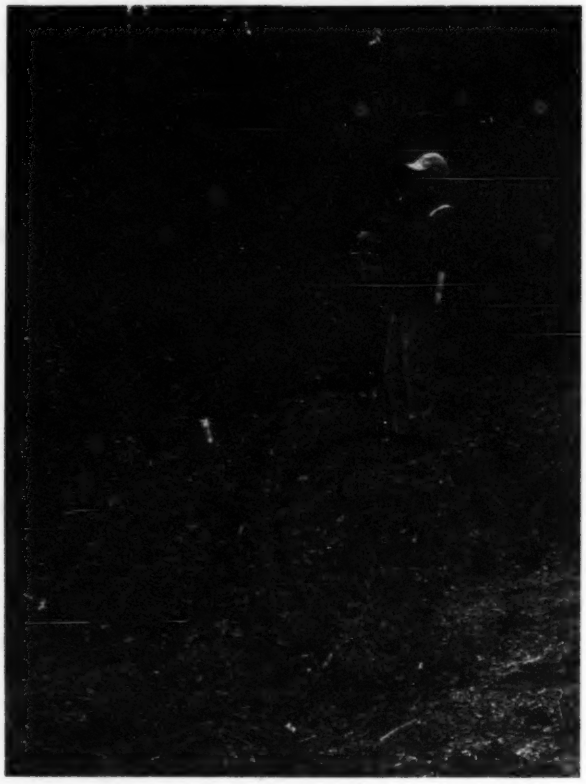
What is your professional claim to fame?
I implemented contour plots for temperature readings taken at a dam during construction. This new reporting style helped to better understand the style and rate of temperature increase during cement setting throughout the dam body.

Where is the most interesting place on Earth that you have worked?
In a tropical jungle in Colombia.

What is your favourite geological place/feature in Alberta?
The Rocky Mountains.

Why did you pick your career?
I was drawn by the possibility to change communities and improve the residents quality of life with the projects that engineers can create. ❖

Meet Our Staff
Todd Shipman, Geologist



How long have you been with AGS?
I have been here since August 2010.

What is your field of expertise?
I am a sedimentologist, with expertise in basin analysis and remote sensing.

What is your professional claim to fame?
Earliest known bee-like trace first recognized by me, but yet to be named.

Where is the most interesting place on Earth that you have worked?
Vallie de la luna, Argentina

What is your favourite geological place/feature in Alberta?
Caribou Mountains

Why did you pick your career?
To make road trips more interesting. ❖

Dr. Mark Fenton Receives SAGE Award

Photo courtesy of SAGE.

Alberta Geological Survey's Mark Fenton has been awarded the Seniors Association of Greater Edmonton Award for Science and Technology, which recognizes contributions to the advancement of science and technology. The Seniors Association of Greater Edmonton (SAGE) Awards are the first in Canada to recognize seniors for their contribution to our community in their senior years.

The award recognizes Mark's many activities in educating the public on geology, such as leading geo-walks at Miquelon Lake Provincial Park and assisting the Royal Alberta Museum with its new Earth History gallery.

According to Mark, his nomination was serendipitous. Lily Simpson, a SAGE member, found out about Mark's volunteer activities by word of mouth and asked for more information. He sent her a copy of our Fall 2010 Rock Chips with the article on being awarded the provincial geologist medal. Based on that, Lily asked for a biography and reference letters and submitted his nomination to the awards committee.

Not only has the award made citizens aware of AGS activities, Mark is also pleased that a senior member of the Earth sciences community has been recognized. He hopes this will inspire other seniors.

The SAGE Awards celebrate seniors who inspire, empower and engage others in making our community a better place to live, work and play. For more than 40 years, SAGE has provided a broad range of programs, services and publications that enhance the quality of life for seniors in our community.

More information on SAGE and the awards can be found at www.mysage.ca. ❖

Recently Released Publications

http://www.ags.gov.ab.ca/publications

Open File Reports

OFR 2011-09 Inorganic Water Chemistry of Saline Fens in Northeastern Alberta (NTS 74D)

Digital Datasets

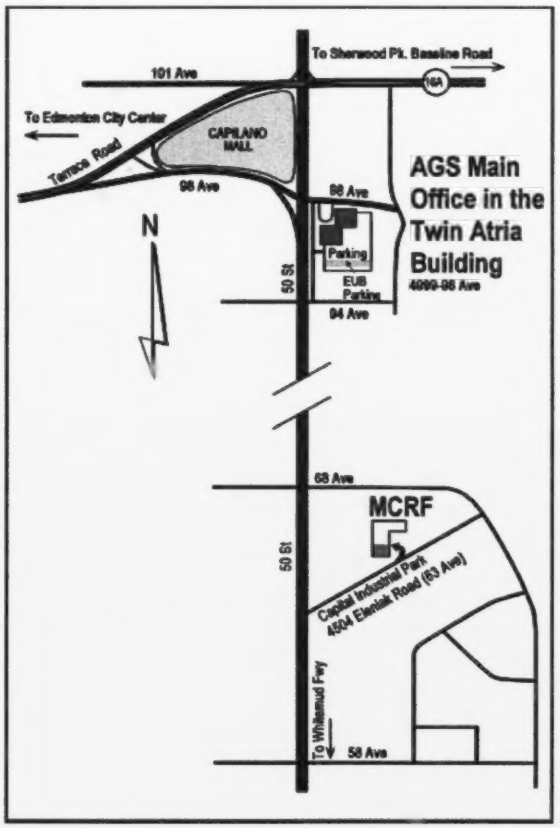
DIG 2011-0001 Stratigraphic and Lithological Picks of the Uppermost Geological Units in the Athabasca Oil Sands Area (tabular data, tab-delimited format)

DIG 2011-0007 Water Geochemical Data, Saline Aquifer Project (tabular data, tab delimited format)

Come Visit Our Booth

AMSC Trade Show
September 28 - 29, 2011
TELUS Convention Centre
Calgary, Alberta
Visit us at booth number 204. The ERCB's St. Albert office will be right next to us in booth number 202.

Canadian Unconventional Resources Conference
November 15 - 17, 2011
BMO Centre at Stampede Park
Calgary, Alberta
Visit us at booth number 210.



AGS Locations

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